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STEAM TREATMENT OF ORCHARD BOXES TO DESTROY CODLING MOTH LARVAE

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Introduction

In the Pacific Northwest wooden boxes are used in the orchards as containers for the harvested fruit. Many of these boxes are used more than once, and when employed in apple orchards, and especially for carrying cull apples to by-products plants, they frequently become the hibernating quarters of large numbers of codling moth larvae. At the close of the season these boxes are stored over winter out of doors in piles of about 25,000 or more, and since the temperature within these piles remains low the following season, the larvae are often still in the boxes when they are taken out for use in harvesting early fruits, such as cherries or pears. Moths emerging from such boxes constitute an important source of infestation to nearby apple or pear orchards. Wherever codling moth control is a difficult problem, it is essential that every possible means of eliminating sources of infestation such as this one be taken.

The Apple Growers Association at Hood River, Oreg., in cooperation with Leroy Childs, of the Hood River Experiment Station, devised a tunnel in 1929 through which boxes could be passed and heated by means of steam. This apparatus was reported to destroy the codling moth larvae effectively at a low cost. Some experiments were conducted by Childs,[1] but it was felt that further experiments were needed. These were therefore made at Yakima, Wash.

Description of Boxes

Ordinary packing boxes made of light material are most commonly used in the orchards. Cannery lug boxes are also used; these are heavier and

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[1] "Codling Moth Control in Steamed Picking Boxes," by Leroy Childs, Hood River Experiment Station, 1933 (unnumbered mimeographed circular).

have triangular braces in each corner and cleat handles across the top at each end. They also have more cracks for favorable cocooning quarters than the packing boxes. They are used almost exclusively for handling cull fruit. Some apple packing houses use heavy lug boxes the same size and shape as the packing boxes but with corner braces and no handles. The bottoms are solid and the sides and ends slatted. These boxes do not have as many protected cocooning places as the cannery lug boxes.

Number of Larvae Found in Boxes

Practically all used fruit boxes contain many hibernating larvae. No attempt was made to obtain an average for all boxes, but information was obtained from the boxes used in the experiments described below. These were selected from piles of boxes known to have been used for cull apples, hence the figures given below are probably above the average for all boxes. The packing boxes used contained an average of 9.5 and a maximum of 71 larvae per box. The cannery lugs averaged 14.6 larvae each, with a maximum of 87. Packing house lugs contained an average of 2.3 larvae per box, and 11 was the most found in one box.

Laboratory Steaming Experiments

Preliminary tests were made by steaming, in an oven, larvae hibernating in corrugated paper strips. It was found that 100 percent could be killed in 1 minute at 180° F. air temperature, in 1½ minutes at 160°, and in 2 minutes at 150°.

Large-scale Steaming Equipment

The Yakima Fruit Growers Association became interested in the possibility of steaming boxes and offered to construct a tunnel which could be used for experimental work and later for practical sterilization of boxes. This tunnel was of wood, insulated with celotex, with a roller conveyor in the bottom, and steam pipes in each corner which were perforated every foot. The tunnel was 20 feet long, 20 inches wide, and 12 inches high in order to accommodate the boxes transversely, since an apple box is 19½ inches long and 11 inches high. For larger or smaller boxes, the dimensions of the tunnel would have to be different. Steam was supplied from an oil-burning boiler (fig. 1).

Tests 4 to 8, 10, and 11 in the tables were made with this equipment. Later, the length of the tunnel was increased to 40 feet in order to increase the length of exposure somewhat as well as to increase the number of boxes that could be handled. Tests 1 to 3, 9, and 12 to 18 were made in this longer tunnel. This equipment was portable, so it could be moved easily from one packing plant or box pile to another.

Experimental Procedure

Enough boxes were selected to contain an estimated minimum of about 100 larvae for each test. The tunnel was first heated to a temperature

somewhat above that desired for the test, and a number of other boxes were put through in front of the test boxes. This was necessary, since the continuous flow of cold boxes into the tunnel lowered the temperature. When an even temperature and the desired speed for moving the boxes through the tunnel had been established, the test boxes were put through. Boxes were placed on an extension of the conveyor one at a time and pushed forward by hand so that the line of boxes within the tunnel moved forward with each push the width of one box, or about 1 foot.

Temperatures were taken from four thermometers inserted through the top of the tunnel. These readings were checked by sending a maximum recording thermometer through the tunnel in a box and comparing the reading from this with the highest reading noted on the top thermometers. There was seldom more than 2 degrees difference between the two.

The four thermometers in the top of the tunnel were read at the beginning of each test and again at the end, making eight readings, which were averaged. These averages, however, are not very satisfactory, as they are materially lowered by the reading of the thermometer nearest the end where the cold boxes are introduced. The other three thermometers registered temperatures close to the maximum, and this maximum is a better guide than the average.

The boxes were examined for larval mortality from 1 to 3 days after treatment. All joints were pried apart and all cracks carefully examined in order not to miss any of the larvae. Untreated boxes were examined to determine the extent of natural mortality. This check was found to be unnecessary, since all larvae already dead were dry and discolored and were easily distinguishable from those killed by the steam treatment.

The results of steam-treating larvae in orchard boxes are shown in table 1.

Table 1.--Results of steaming overwintering codling moth larvae in orchard boxes, Yakima, Wash.

Test No.	Time of exposure, minutes	Average temperature, °F.	Maximum temperature, °F.	Total larvae	Number dead	Percent dead
		Apple Packing Boxes				
1	4	173	196	109	109	100.0
2	4	180	198	75	75	100.0
3	3	192	207	129	129	100.0
4	1½	184	186	143	142	99.3
5	2	186	194	187	181	96.8
6	1	191	200	166	153	92.2
7	1	188	204	195	179	91.8
8	2¾	165	174	94	78	83.0
9	3	148	172	137	110	80.3
10	1½	175	184	128	89	69.5
11	2	160	170	216	137	63.4
		Cannery Lug Boxes				
12	4	199	203	244	242	99.2
13	3	192	207	90	88	97.8
14	4	183	201	65	62	95.4
15	2	203	208	133	123	92.5
16	4	181	200	106	97	91.5
17	3	168	190	207	19	9.2
		Packing House Lug Boxes				
18	4	200	206	60	60	100.0

Discussion of Results

Since it requires some time for heat to penetrate the wooden boxes, it was necessary to expose them longer and at a higher temperature than was indicated in the preliminary tests. Packing boxes are those most easily treated. An exposure of 2 minutes at 200° F. maximum temperature seems to be about the minimum requirement to kill all the larvae, although no test of this exact exposure was made. Cannery lug boxes were more difficult to treat. A mortality of 100 percent was not accomplished, but most of the worms were killed in 4 minutes at 203° F. or in 3 minutes at 207°. Only one test of packing house lug boxes was made, and this resulted in 100 percent kill in 4 minutes at 206° F. It would be expected that these boxes should require a treatment somewhere between the packing boxes and cannery lug boxes, since they are intermediate in weight.

An attempt was made to steam the boxes in nests of three as they are commonly stacked, but this was unsatisfactory because the heat did not penetrate to the inner box.

Later Improvements in Equipment

Since the tests reported in this paper were conducted some improvements have been made in the steaming equipment. The tunnel has been lined with galvanized iron, which prevents the celotex from becoming wet and losing its insulating property. A mechanical "pusher" has been added to facilitate the movement of boxes through the tunnel. This consists of a plunger operated by a crank and driven by an electric motor. The plunger pushes against the line of boxes on the conveyor and advances them the width of a box at each thrust. A box is added in front of the plunger each time it recedes. Twenty boxes per minute are handled with this machine, and since there are 40 boxes in the tunnel each box is exposed 2 minutes. The temperature is easily held at 210° to 215° F. by superheated steam from a 20-horsepower boiler, burning coal. The steam is introduced through perforated pipes running along the lower corners of the tunnel. The temperature used is somewhat above the minimum requirement for 2 minutes as shown by the tests and assures complete mortality of the larvae.

The Yakima Fruit Growers Association has used this equipment for three seasons and has treated more than a million boxes with it. They report that the treatment is satisfactory and that it does not appreciably injure the boxes.

Cost of Steaming

The cost of operating the steaming equipment is not very great. The oil burner requires from 2 to 3 gallons of diesel oil per hour, which at 7 cents per gallon amounts to $1.12 to $1.68 for an 8-hour day. From 2 to 6 men are required to operate the steamer, depending upon the arrangement. At $3 per day for each man, the total cost of labor and fuel would be from $7.12 to $19.68. In actual practice about 6,000 packing boxes can be treated

per day at a cost of approximately $1.20 to $3.30 per 1,000. The cost of steaming cannery lug boxes would be about one-third higher than for packing boxes. The coal-burning boiler, which was larger and provided more steam, was operated at about the same cost as the oil-burning boiler. One-third ton of coal, costing $6 per ton, was consumed per day.

The cost of building the 40-foot tunnel was about $50. A used coal-burning boiler was purchased and put in condition for operation at a cost of $125. The cost of steam boilers varies widely. A cannery employing a steam tunnel similar to the one described uses steam from the main heating plant at very little cost.

Figure 1.--Portable equipment for steaming orchard boxes. Boxes are introduced into tunnel at far right and come out at left end of tunnel (center of picture). Steam from boiler is introduced through hose at center of tunnel.